# Space Weather Technical Forecast

Issued on Tuesday, 10 January 2023 at 12:01 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: M-class flares likely, chance of X-class flares throughout. A possible glancing blow from a CME on the 12th January.**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity has been High over the past 24 hours, with an X1.9 flare observed at 09/1850 UTC, which originated from AR3184 near the southeast limb.

There are currently seven numbered sunspot regions on the visible disc, with one un-numbered region. AR3182 (Eki/Beta-Gamma-Delta) in the southeast quadrant and AR3181 (Eki/Beta-Gamma-Delta) in the southwest are currently the two largest and most complex regions on the disc. AR3181 has a small delta spot in its leader portion. AR3182 also has a small delta spot in its main leader portion, with two further small delta spots in its trailer portion. There is some evidence of slight overall decay in recent imagery. AR3184 continues to rotate into the SE quadrant and has tentatively been classified as a Dkc/Beta-Gamma-Delta configuration, however foreshortening continues to make accurate analysis difficult. A newly numbered region at the northeast limb, 3186, produced an M5 flare at 10/0016UTC, again this region is difficult to analysis due to foreshortening effects. Some small spot emergence is also noted in the northeast quadrant.

An M2 flare on 9th Jan from AR3181 in the southwest did produce a CME, which has been analysed and may give a glancing blow at Earth on day 3 (12th Jan), although this is a low probability. No other Earth-directed CMEs are in the forecast.

**Solar Wind / Geomagnetic Activity:** Solar winds, as observed by DSCOVR at L1, have been at slow ambient levels through the period, 320-400km/s. Density was average or below average. Total IMF, Bt, was predominantly weak, but with a slight upward drift, peak at 9 nT. The north-south component, Bz, showed a similar drift from often negative (southward) to positive (northward) but was weak, +8/-5 nT. Phi angle was negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2) throughout.

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) as measured at GOES-16 was at background levels, although with a small, short enhancement observed just after midnight UTC. High energy electron flux (greater than 2 MeV) has been at background to moderate levels, with a peak of 301 pfu observed at 09/1815 UTC. The 24-hour integrated electron fluence stayed well below the Active threshold, reaching 3.91e6 integrated pfu at 10/0001 UTC.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Solar activity is likely to be Moderate, with a chance of X-class flares through the forecast period, these most likely from AR3182, AR3181, AR3184 or AR3186 which is currently emerging around the northeast limb.

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# Met Office Space Weather Technical Forecast

**Solar Wind / Geomagnetic Activity:** The M2 flare on 9th Jan from AR3181 in the southwest did produce a CME, which has been analysed and may give a glancing blow at Earth on day 3 (12th Jan), although this is a low probability. No other Earth-directed CMEs are in the forecast.

Solar wind speeds are now at ambient levels. However, the next feature of interest is CH62/-, with the HSS likely to arrive on Day 1 (10 Jan). Geomagnetic activity is expected to be mostly Quiet at first, increasing with the HSS arrival on Day 1 to become Unsettled to Active, with a slight chance of a G1/Minor Storm. Activity then slowly declining through by day 2 (11th Jan) and possibly day 3 (12th Jan), although there is the slight chance of a glancing blow from aforementioned CME, which may increase geomagnetic activity, potentially lasting into day 4 (13th Jan), before gradually declining.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux observed by GOES-16 is likely to remain at background levels throughout. However, there is a risk of an increase should any significant flares occur, giving a slight chance of exceeding the S1/Minor Storm threshold. Electron fluence is likely to remain below the Active (1e8 integrated pfu) threshold, but a rise is possible towards the end of the period, depending on extent of coronal hole influence, and any glancing CME on day 3 (12th Jan).

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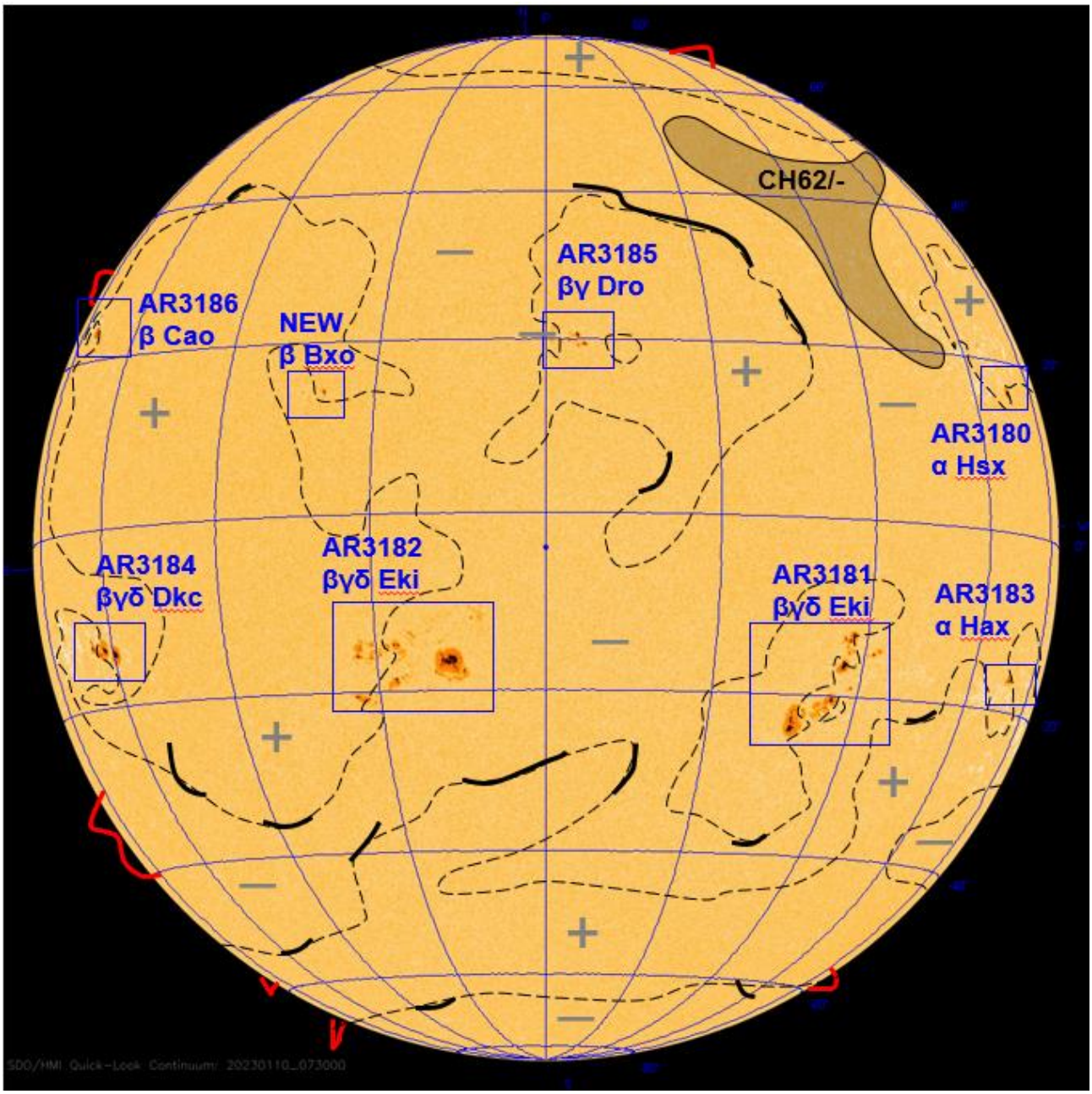
**Figure 1. Solar Analysis Valid 10/0800 UTC.**

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**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

AR3181 in the southwest produced an M2 flare, observed at 09/0901 UTC, which produced a CME. This has been analysed and may give a glancing blow at Earth on Day 3 (12 Jan), although this is low confidence. No other Earth-directed CMEs are currently expected in the forecast.

Solar wind speeds are at ambient levels. The next feature of interest is CH62/-, with the HSS likely to arrive on Day 1 (10 Jan). This feature was faintly visible on the previous rotation but didn't produce a HSS. It is much more clearly visible this time around, suggesting it is more intense and therefore more likely to give an increase in wind speeds on this rotation. The timing of arrival has been estimated from empirical techniques due to the lack of persistence data, but recent STEREO-A data suggests it is unlikely to arrive until at least later on Day 1 (10 Jan). MOSWOC Enlil is currently bringing the HSS in too early, with this suggesting it should have already arrived.

Geomagnetic activity is expected to be mostly Quiet at first, increasing with the HSS arrival on Day 1 (10 Jan) to become Unsettled to Active, with a slight chance of a G1/Minor Storm. Activity then slowly declining on Day 2 (11 Jan), before possibly increasing again on Day 3 (12 Jan) due to a potential glancing blow from a CME - however this is low confidence. Becoming mostly Quiet to Unsettled on Day 4 (13 Jan).

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 20 | 5 | 10 | 5 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 19/1908 | Partial | AR3181 | S30W31 | 445 | 12/2100 | Low probability/low confidence of glancing blow |

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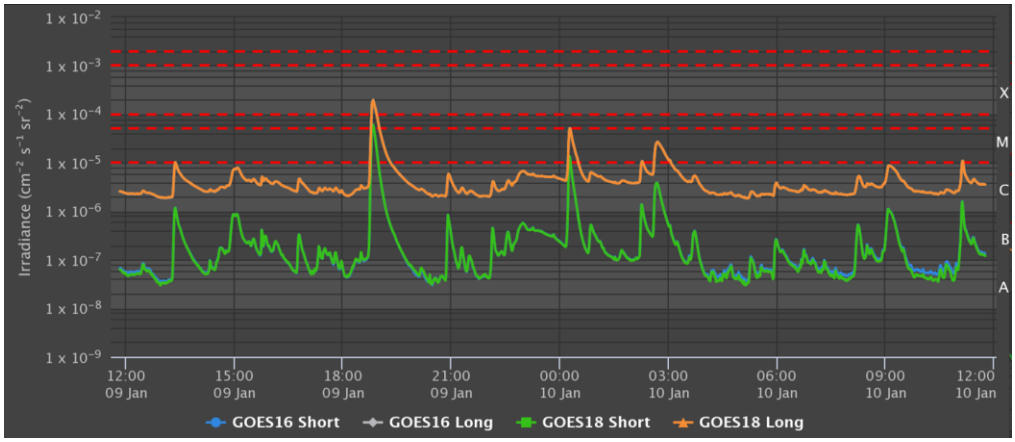
## Radio Blackouts - X-Ray Flares:

There are currently seven numbered sunspot regions on the visible disc, with one un-numbered region. AR3182 (Eki/Beta-Gamma-Delta) in the southeast quadrant and AR3181 (Eki/Beta-Gamma-Delta) in the southwest are currently the two largest and most complex regions on the disc. AR3181 has a small delta spot in its leader portion. AR3182 also has a small delta spot in its main leader portion, with two further small delta spots in its trailer portion. There is some evidence of slight overall decay in recent imagery. AR3184 continues to rotate into the SE quadrant and has tentatively been classified as a Dkc/Beta-Gamma-Delta configuration, however foreshortening continues to make accurate analysis difficult. A newly numbered region at the northeast limb, 3186, produced an M5 flare at 10/0016UTC, again this region is difficult to analysis due to foreshortening effects. Some small spot emergence is also noted in the northeast quadrant.

Solar activity has been High over the past 24 hours, with AR3184 producing an impulsive X1.9 flare, observed at 09/1850 UTC. This caused R2-R3 radio blackouts on the Sun facing side of Earth. However, this event did not produce a CME. Several other M-flares were observed, the largest an M5 flare at 10/0016UTC, from the newly numbered sunspot, 3186, at the northeast limb. Solar activity is likely to be Moderate with a chance of X-class flares. AR3182, AR3181, AR3184 or 3186 are the most likely regions to produce further significant flares.
Far side seismographs are also indicating plenty of additional potential activity on the far side.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 70 | 70 | 70 | 70 |
| Very Active | R3 to R5 X Class | Yes | 25 | 25 | 25 | 25 |

**Figure 2: GOES16 X-ray flux plot.**

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## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 has been at background levels, although with a small, short enhancement observed just after midnight UTC. However, any significant flares will bring a risk of proton flux rising, with a slight chance of exceeding the S1/Minor Storm threshold. This is mainly due to the risk presented by both AR3182 and AR3181 as they are now rotating further westwards across the disc, towards a position where they are more likely to connect with Earth for proton storm events. AR3184 will also bear watching in the coming days, depending on how it appears as it rotates more fully onto the disc.

| Radiation Storms<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 20 | 20 | 20 | 20 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at background to moderate levels. Electron flux levels may rise a little in the next couple of days, but this is expected to be modest, perhaps reaching Moderate levels at the diurnal peaks. The onset of the next HSS from CH62 on Day 1 (10 Jan) is expected to cause a continued suppression of flux levels. This HSS is expected to be stronger than on previous rotation, with any electron response more likely to occur towards the end of this four day period - depending on any glancing blow from a CME on day 3 (12 Jan) which may keep electron flux levels suppressed.

Electron fluence is therefore expected to remain below the Active (1e8 integrated pfu) threshold through the period. Confidence in fluence remaining below Active through most of the period is reasonable, but lower for the likelihood and timing of any increase especially towards the end of the period, due to the xtent of any coronal hole influence, and a possible glancing blow from a CME on the 12th Jan.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 5 | 10 | 20 | 20 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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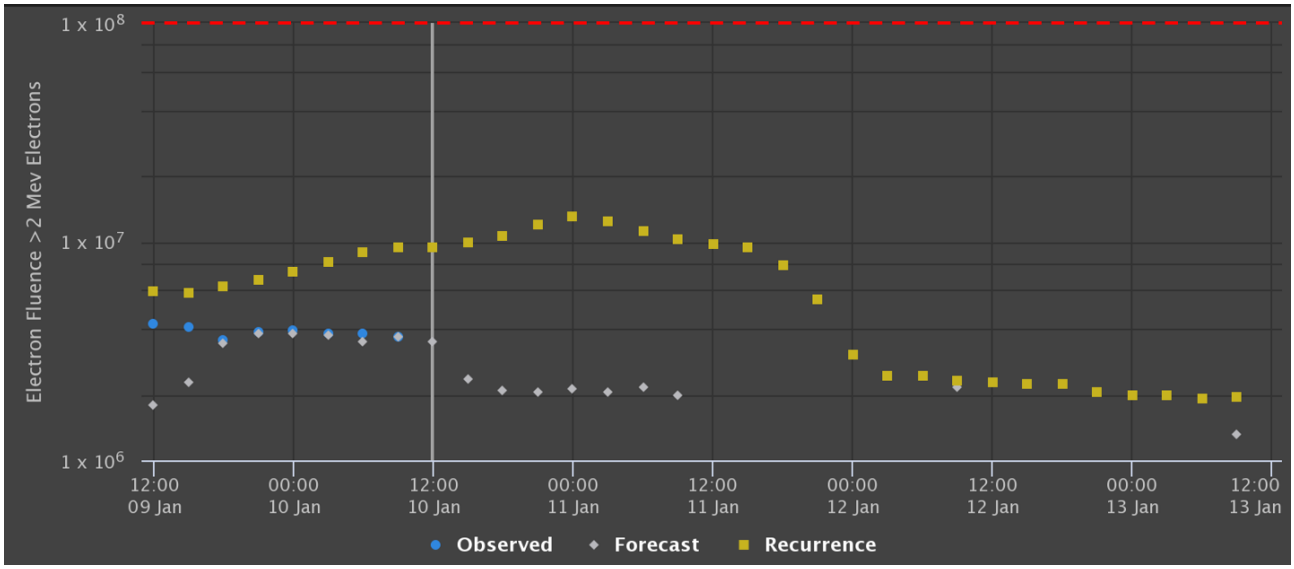
**Figure 3: MOSWOC REFM latest output.**

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